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HYDROGEN ENERGY

A BIBLIOGRAPHY WITH ABSTRACTS

QUARTERLY UPDATE
JULY-SEPTEMBER 1977

PREPARED BY THE

ENERGY INFORMATION PROGRAM

of the

TECHNOLOGY APPLICATION CENTER

OCTOBER 1977

THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO

A DIVISION OF THE INSTITUTE FOR APPLIED RESEARCH SERVICES (IARS)

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PREFACE

HYDROGEN ENERGY is a continuing bibliographic summary with abstracts of research and projections on the subject of hydrogen as a secondary fuel and as an energy carrier. The first volume was published in January, 1974 and is cumulative through December of 1973. Additional copies are available from the Technology Application Center, as are the quarterly update series for 1974, 1975, 1976 and the first two quarters of 1977.

This update to HYDROGEN ENERGY cites additional references identified during the third quarter of 1977. It is the third in a 1977 quarterly series intended to provide "current awareness" to those interested in hydrogen energy.

For the reader's convenience, a series of cross indexes are included which track directly with those of the cumulative volume. See "Guide to Use of the Publication."

A library containing some of the articles and publications referenced in this update and the cumulative volume has been established and the Center will, on a cost-recovery basis, aid readers to obtain copies of any cited material. Although a considerable effort has been made to insure that the bibliography is complete, readers are encouraged to bring any omissions to the attention of this Center.

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--An INDEX OF AUTHORS alphabetized by author's last name. A reference's author is followed by the reference's citation number. For multiple authors, each author is listed in the index.

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CONTENTS (continued)

I. GENERAL: CONCEPTS, CONFERENCES, SURVEYS, REVIEWS

H77 10282 ENERGY FACT BOOK-1977

Anon, (Tectra Tech Inc., Arlington, VA), 446 p., Apr 1977, TETRAT-A-642-77-306, AD-A038 802/5WE

The Energy Fact Book-1977 summarizes the present U.S. Energy situation; Energy R and D Legislation; Federal Government Energy R and D; and International Energy R and D. It includes a brief description of the various processes and developments related to hydrocarbon fuels, synthetic fuels, non-hydrocarbon energy sources and energy conservation.

(U.S. ENERGY RESOURCES, DEVELOPMENTS, LEGISLATION)

H77 10283 THE HYDROGEN ECONOMY: A PRELIMINARY TECHNOLOGY ASSESSMENT

Dickson, E.M., Ryan, J.W., Smulyan, M.H., (Stanford Research Inst., Menlo Park, CA), NSF/RA-760491, 407 p., Feb 1976, PB-266 607/1WE

Hydrogen must be manufactured from basic energy resources since it is not a naturally occurring energy form. This report addresses the question of the feasibility of the use of hydrogen as a fuel. Although it is generally believed that hydrogen might soon become less expensive than petroleum, competition along fuels in the energy marketplace and the need to derive hydrogen from other energy sources will insure that hydrogen does not become less expensive than alternatives for a very long time. Transitions involving change in basic infrastructure technologies, systems and institutions are difficult to effect because new, embryonic systems must compete with established systems, often at a price disadvantage. This report includes the following: (1) summary and recommendations; (2) technology assessment and energy in the future; (3) hydrogen technologies, present and projected; (4) competing and complementing technologies, present and projected; (5) economics of hydrogen; (6) transition to a hydrogen economy; and (7) consequences of a hydrogen economy.

(TECHNOLOGY ASSESSMENT, HYDROGEN ECONOMY, FEASIBILITY)

H77 10284 STATUS OF THE HYDROGEN-ENERGY SYSTEM CONCEPT

Gregory, D.P., (Institute of Gas Technology, Chicago, IL), 25 p., 1976, World Gas Conference; London, United Kingdom of Great Britain and Northern Ireland, United Kingdom, June 7, 1976, CONF-760681-1

Much attention has been given to the concept of using hydrogen as a gaseous carrier of energy produced from the new sources, such as nuclear and solar, to conventional energy users. The natural gas industry has an opportunity to share in the delivery of the energy from these new sources by using its existing pipelines and marketing capability to distribute hydrogen, if hydrogen fuel is truly a viable concept. This paper reveiws the status of the considerable research on the electrochemical and thermochemical production; pipeline transmission, cryogenic, hydride, and pressure storage of hydrogen; and on the use of hydrogen as a fuel for vehicles, aircraft, and other domestic purposes.

Before hydrogen can take its place as a useful and economical energy carrier, more technical information is needed in areas of pipeline and compressor materials, compatibility of distribution systems, and tolerance of utilization devices to mixtures of hydrogen and methane and considerably more effort must be devoted to developing hydrogen-production techniques that will reduce hydrogen's cost.

(DISTRIBUTION, PRODUCTION, STORAGE)

H77 10285 HYDROGEN ENERGETICS AND FUEL CELLS

Gurevich, I.G., Skundin, A.M., (Inst of Heat and Mass Exchange, Minsk), Vestsi Akad. Navuk BSSR, Ser. Fiz.-Energ. Navuk, p. 46-54, N3, 1976
In Russian

A short historical survey of the problem of fuel cells (firstly, hydrogen-oxygen fuel cells) is made, and the perspectives of their development are discussed.

(FUEL CELLS, HISTORY, DEVELOPMENT)

H77 10286 INEXHAUSTIBLE RESOURCES

Herman, S.W., Cannon, J.S., (INFORM, Inc., New York, NY), Inexhaustible Resources of In Energy Futures: industry and the new technologies, p. 17-257, 1976

This section, Section I, summarizes information on nondepletable resources of solar heating and cooling, solar cells, solar thermal electric conversion, ocean thermal electric conversion, wind generators, nuclear fusion, and hydrogen production. Each of the seven chapters consists of two parts--an overview, or general introduction to the status of the technology, followed by from 3 to 34 individual profiles of companies' projects in the technology. The overview summarizes data on the technology, the environmental impact, the history, obstacles to commercilization, Federal and private programs, and a brief prognosis of the technology's future.

(TECHNOLOGY ASSESSMENT, ENVIRONMENTAL IMPACT)

H77 10287 ENERGY AND PHYSICS

Kapitsa, P.L., 12 p., 1976, Translated from Usp. Fiz. Nauk, V 118:307-314, N2, 1976, ERDA-tr-225

The energy crisis shows the need for additional energy sources. The cost effectiveness of various solutions to energy probelm are discussed. Hydrogen fuel cells are very efficient, but the extremely small rate of diffusion in electrolytes renders the energy density very small. The best solution, according to the author, is fusion. Ion heating is a terrific problem, especially in Tokamaks. But there seem to be no fundamental obstacles, and hopefully more research will make fusion the answer to the energy problem.

(COST EFFECTIVENESS, FUSION, HYDROGEN FUEL CELLS)

H77 10288 HYDROGEN: AN ENERGY CARRIER WITH A FUTURE

Keller, C., Bild Wiss., V 13:76-82, N10, Oct 1976, In German

The article outlines the prospects and problems of the present discussed chemical secondary energy carrier hydrogen and indicates the important advantages of a hydrogen economy. It deals with its release from water by means of electrolysis and thermochemical cycle processes, treats safety aspects and problems of transport and storage as well as the use or usability as fuel for vehicle, plane and rocket and finally assesses how many 3,000 MGW high-temperature nuclear reactor plants would be necessary in order to replace all of the fossil fuels by hydrogen in the year 2,000.

(HYDROGEN ECONOMY, DISTRIBUTION, SAFETY, UTILIZATION)

H77 10289 ENERGY RESEARCH AND DEVELOPMENT PROGRAM PREPARED BY THE GOVERNMENT OF THE FEDERAL REPUBLIC OF GERMANY ANNUAL REPORT 1975

Anon, (Kernforschungsanlage Juelich G.m.b.H., Germany), 540 p., 1975, NP-21444

This report is a continuation of the 1974 report; an account of the non-nuclear Energy R and D Program 1974-1977 is provided by means of a listing, description and status summary of each sponsored project. The industrial concerns or institutions responsible for each project, as well as the chief subcontractors, and the total cost of each project and the government contribution are also given. Project specifications of program priorities are included for: coal conversion, mining technology and coal preparation; prospecting and disclosure of oil and gas; conversion, transport, and storage of energy; and efficient utilization of energy. The chief aims of the program are: to reduce dependence on crude oil imports; a reduction in energy losses; and securing a long-term supply of energy from various sources.

(NON-NUCLEAR ENERGY RESEARCH, ENERGY PROJECTS, ENERGY SUPPLY)

H77 10290 PRODUCTION OF HYDROGEN FROM NUCLEAR ENERGY

Gregory, D.P., (Institute of Gas Technology, Chicago, IL0, 18 p., 1975 Synthetic Pipeline Gas Symposium, Chicago, IL, Oct 27, 1975

The use of nuclear energy in the production of hydrogen by electrolysis, thermochemical processes, hybrid thermochemical/electrochemical processes, nuclear irradiation, and nuclear-assisted production from fossil fuels is discussed.

(ELECTROLYSIS, THERMOCHEMICAL PRODUCTION, HYDRIDE PROCESSES)

H77 10291 SOLAR THERMAL POWER PLANTS

Anon, Solar Energy. Storage: Making H While the Sun Shines, Mosaic, V 5:23, N2, Spring 1974

The production of hydrogen by solar and wind power plants as means of energy storage is mentioned.

(POWER PLANTS, SOLAR, WIND)

II. PRODUCTION

H77 20569 A PRELIMINARY SYSTEMS-ENGINEERING STUDY OF AN ADVANCED NUCLEAR-ELECTROLYTIC HYDORGEN-PRODUCTION FACILITY FINAL REPORT

Escher, W.J.D., Donakowski, T.D., Tison, R.R., (Institute of Gas Technology, Chicago, IL), NASA-CR--144230, 101 p., Dec 1975, (Contracts NAS8-30757; IGT PROJ. 8962)
Avail:NTIS $5.50

An advanced nuclear-electrolytic hydrogen-production facility concept was synthesized at a conceptual level with the objective of minimizing estimated hydrogen-production costs. The concept is a closely-integrated, fully-dedicated (only hydrogen energy is produced) system whose components and subsystems are predicted on "1985 technology." The principal components are: (1) a high-temperature gas-cooled reactor (HTGR) operating a helium-Brayton/ammonia-Rankine binary cycle with a helium reactor-core exit temperature of 980°C, (2) acyclic d-c generators, (3) high-pressure, high-current-density electrolyzers based on solid-polymer electrolyte technology. Based on an assumed 3,000 MWt HTGR the facility is capable of producing 8.7 million std cu m/day of hydrogen at pipeline conditions, 6,900 kPa. Coproduct oxygen is also available at pipeline conditions at one-half this volume. It has further been shown that the incorporation of advanced technology provides an overall efficiency of about 43%, as compared with 25% for a contemporary nuclear-electric plant powering close-coupled contemporary industrial electrolyzers.

(NUCLEAR-ELECTROLYTIC PRODUCTION, ADVANCED FACILITY, SYSTEMS STUDY)

H77 21131 MULTI-STEP CHEMICAL AND RADIATION PROCESS FOR THE PRODUCTION OF GAS

Anon, (Texas Gas Transmission Corp.), 8 p., Feb 10, 1976, Netherlands Patent 7,601,343/A, In Dutch

The invention discloses a multi-step chemical and radiolytic process for the production of gas such as hydrogen and oxygen. A highly radiosensitive gas such as carbon dioxide is injected directly onto the reaction chamber of a fusion reactor and is molecularly dissociated to form carbon monoxide and pure oxygen when the fusion fuel is burned. The carbon monoxide is then mixed with steam at an elevated temperature to form carbon dioxide and pure hydrogen. The carbon dioxide is recycled and injected into the central reaction chamber to complete a closed-loop process for production of pure hydrogen and oxygen at the expense of water.

(RADIATION PROCESS, CHEMICAL REACTION, FUSION REACTOR)

H77 21132 PROCESS FOR THERMOCHEMICALLY PRODUCING HYDROGEN

Bamberger, C.E., Richardson, D.M., (ERDA), 6 p., Dec 7, 1976, Filed date Jan 27, 1976, US Patent 3,996,343

Hydrogen is produced by the reaction of water with chromium sesquioxide and strontium oxide. The hydrogen producing reaction is combined with other reactions to produce a closed chemical cycle for the thermal decomposition of water.

(THERMAL DECOMPOSITION, CHRONIUM OXIDE, STRONTIUM OXIDE)

H77 21133 THERMOCHEMICAL PRODUCTION OF HYDROGEN - MYTH OR REALITY

Donat, G., Esteve, B., Roncato, J.P., (Gaz de France, Direction des Etudes et Techniques Nouvelles, Paris, France), Revue de L'Energie, V 28:252-268, April 1977, A77-32593, In English and French

A computer approach to discovering economically attractive thermochemical cycles for producing hydrogen from water is described. A thermochemical system would do away with prior production of electricity (required by electrolytic processes for generating hydrogen) by making direct use of heat through a series of chemical reactions which consume only water on an overall basis, since all compounds other than hydrogen and oxygen are reformed by the time the cycle repeats itself. A thermochemical cycle is similar to a heat engine which produces a certain amount of potential work in the form of oxygen and hydrogen. The computer search used the variation of the free enthalpy function G rather than the enthalpy function H and analyzes irreversible processes. No thermochemical cycle competitive with electrolytic techniques was discovered. Although hybrid cycles which involve the use of some external electricity have not been fully analyzed. French future research willfocus on electrolytic techniques for generating hydrogen.

(THERMOCHEMICAL CYCLES, COMPUTER ANALYSIS, GIBBS FREE ENERGY)

H77 21134 REACTIONS IN THE ZNSE THERMOCHEMICAL CYCLE FOR HYDROGEN PRODUCTION

Pearson, R.K., Krikorian, O.H., Elson, R.E., Condit, R.H., (California, University, Livermore, CA), Dreyfuss, R.M., (Hostos Community College, Bronx, NY), I & EC - Industrial and Engineering Chemistry, Product Research and Development, V 16:70-78, Mar 1977, W- 405-ENG-48, A77-24854

The two key steps in the ZNSE thermochemical cycle for hydrogen production from water have been experimentally studies in some detail. In the more critical step of the two, ZNO is reacted with SE and SO_2 to form a mixture of ZANSE and $ZNSO_4$. This reaction has been found to proceed quantitatively at 770°K and to reach approximate equilibrium in 30 minutes for the second key step, which requires hydrolysis of ZNSE to give H_2SE, both aqueous H_2SO_4 and HCL were investigated as hydrolysis agents. It was found that HCL is much more effective than H_2SO_4 for this purpose. Other reactions that were given preliminary consideration were (1) the thermal decomposition of $ZNSO_4$, (2) the thermal decomposition of H_2SE and (3) the formation of sulfuric acid from SO_3. On the basis of these studies, it is concluded that the ZNSE cycle is a scientifically feasible method for production of hydrogen from water.

(THERMOCHEMICAL CYCLE, SULFURIC ACID, PYROLYSIS)

H77 21135 FIELDS OF NUCLEAR POWER APPLICATIONS

Laue, H.J., (Gesellschaft fuer Kernforschung m.b.H., Karlsruhe Germany), 18 p., 1975, CONF-7509129--107, AED-Conf--75-769-077, Meeting on nuclear power plant project planning and implementation, Karlsruhe, German, Federal Republic of Germany, Sept 17, 1975
Avail:NTIS

The paper deals with nuclear power application in fields different from electricity generation, i.e. district heating, sea water desalination, coal gasification, and nuclear splitting of water.

(NUCLEAR SPLITTING, POWER PLANTS)

H77 22032 HYGAS PROCESS DEVELOPMENT

Anastasia, L.J., Bair, W.G., (Institute of Gas Technology, Chicago, IL), 8 p., 1976, CONF-761016-5

The HYGAS Process is a high-temperature, high-pressure, fluidized-bed process designed to maximize production of methane gas from all types of coal as a supplement to America's gas supplies. The Institute of Gas Technology conceived the process and the U.S. Energy Research and Development Administration and the American Gas Association are currently funding it. Experimental process development is proceeding in a pilot plant which feeds 3 tons/hr of coal to produce a nominal 1.5 X 10 exp 6 ft exp 3 of pipeline-quality gas per day. Development studies using a Montana lignite containing 1% S have been completed. The gasification of Illinois No. 6 bituminous (ca.3% S) coal has been demonstrated and current work is directed toward gasification of a subbituminous coal from the Rosebud seam.

(HYGAS, COAL GASIFICATION, METHANE PRODUCTION)

H77 22033 METHANATION: WITH HIGH THERMODYNAMIC EFFICIENCY ENERGY RECOVERY

Biery, J.C., (Los Alamos Scientific Lab., Los Alamos, NM), 27 p., Jan 1977, LA-6656-MS

Heat pipes could be utilized in the process of methanating synthesis gas from coal in two important ways. The first is in the methanator itself where the heat pipes are used for catalyst cooling, temperature control and high-temperature isothermal energy recovery. The second involves recovering thermal energy in the exit gas stream from the methanator and using it to preheat the methanator inlet stream and also to produce steam from condensed water from the exit stream. Costs of the methanator and the recuperator appear to be somewhat lower than comparable units designed by El Paso Natural Gas Co. for their methanation plant at the Four Corners area. The extraction of the heat isothermally at high temperature and the efficient recuperation of the energy between the inlet and outlet gas streams make the present unit attractive.

(HEAT PIPES, COAL GASIFICATION, ECONOMICS)

H77 22034 ASSESSMENT OF DOSIMETRY REQUIREMENTS AND TECHNIQUES FOR MEASURING POLYCYCLIC AROMATIC HYDROCARBONS

Hawthorne, A.R., Gammage, R.B., Simpkin, D.J., (Oak Ridge National Lab., TN), 13 p., 1976, CONF-770301-4

A prediction by ERDA is that, within a decade, 10 exp 6 barrels/day of synthetic fuel will come from liquefaction of coal. The coproduction of highly carcinogenic polycyclic aromatic hydrocarbons (PAH) will necessitate much better dosimetry and means of personnel protection than exist today. Traditional techniques for measuring PAH and gas chromatography with mass spectroscopy, and fluorescence spectroscopy. Several newly developed, or developing techniques, may also lend themselves to PAH dosimetry. These include low-temperature Fourier transform infrared spectrometry, time-resolved fluorescence, room-temperature phosphorescence, portable mass spectrometry and second derivative spectrometry. Special emphasis is given to potential use of the second derivative spectrometer for dosimetry purposes. Some of the advantages and limitations of these techniques for characterizing and measuring PAH under various conditions (vapor, liquid, solid or aerosol) are discussed.

(FUEL SYNTHESIS, COAL LIQUEFACTION, CARCINOGENS)

H77 22035 STATUS OF THE HYGAS PROGRAM

Lee, B.S., (Institute of Gas Technology, Chicago, IL), 20 p., 1976, CONF-761064-4

The significant achievements in the continuing development of the HYGAS Process by the Institute of Gas Technology since the last Synthetic Pipeline Gas Symposium in October 1975 are recounted. During this year the following milestones were reached in the HYGAS program: (1) the pretreatment section produced suitable feed to the gasifier from a highly caking bituminous coal during sustained operation; (2) the technical feasibility of operating the integrated HYGAS-Steam/Oxygen gasification system was demonstrated in extended self-sustained operation using highly caking bituminous coal as a feed; and (3) gasification tests with Montana Rosebud seam subbituminous coal were begun in September 1976.

(HYGAS, COAL GASIFICATION, STEAM OXYGEN GASIFICATION)

H77 22036 PRODUCTION OF AMMONIA USING COAL AS A SOURCE OF HYDROGEN Annual Report

Laukhuf, W.L., (Kentucky Univ., Lexington, Inst. for Mining and Minerals Research, KY), 54 p., Oct 1976, PB-259388/7, IMMR12-PD10-76, N77-20613
Avail:NTIS

The economic feasibility of using a coal gasifier as the required hydrogen production step in an ammonia synthesis plant was investigated. If such a technique was found to be feasible, large quantities of natural gas (the normal hydrogen feedstock for ammonia synthesis) could be released for other uses. A thermodynamic equilibrium model was used to predict the amount of hydrogen produced from a high-sulfur Western Kentucky coal feedstock for several coal gasification schemes. It was estimated that several existing gasifiers could produce sufficient hydrogen so that ammonia processed in an integrated coal gasification-ammonia synthesis plant would cost less to produce than the current selling price. Costs to produce the ammonia were as low as $122 per ton. It was also found that other gasifiers, with only slight modifications in operating conditions, could also produce ammonia for less than $200 per ton. Problem areas requiring further study were identified for such an integrated plant.

(COAL GASIFICATION, HYDROGEN FEEDSTOCK, AMMONIA SYNTHESIS)

H77 22037 PARTIAL LIQUEFACTION OF COAL BY DIRECT HYDROGENATION FIFTH QUARTERLY PROGRESS REPORT, JULY-SEPTEMBER 1976

Oberg, C.L., (Rockwell International Corp., Canoga Park, CA, Rocketdyne Div.), 13 p., Dec 2, 1976, FE-2044-15

Twelve additional 1/4-TPH reactor tests were made. Operational problems were largely solved and relatively high conversions were obtained. In addition, the product analysis procedure has been critically reviewed to assure that there are no errors in the methods. None were found. Facility construction of the 1-TPH reactor system is proceeding rapidly but some slippage has occurred.

(HYDROGENATION, COAL LIQUEFACTION, REACTOR TESTS)

H77 22038 FOSSIL ENERGY PROGRAM REPORT, 1975-1976 VOLUME II, COAL GASIFICATION

Seamans, R.C. Jr., White, P.C., (Energy Research and Development Administration, Washington, DC), 111 p., 1976, ERDA-76-10 NTIS $5.50

In addition to an executive summary and a glossary, sections dealing with the following topics are included: Carbon Dioxide Acceptor Coal Gasification Process; Bi-Gas Process for the Generation of Pipeline Gas; Pipeline Gas by Hydrogasification (Hygas Process); Steam-Iron System for Production of Hydrogen; Synthane Process; Agglomerating Burner Process; Liquid Phase Methanation Combustion and Gasification Process; Advanced Coal Gasification System for Electric Power Generation; Low-Btu Gasification of Coal for Electricity Generation; Coal Gasification Combined-Cycle System for Electric Power Generation; Low-Btu Fuel Gas; Desulfurization of Low-Btu Producer Gas; Technical and Engineering Services; the Coal Conversion System Technical Data Book; and Computer Modeling of Coal Gasification Reactors

(HYDROGASIFICATION, COAL GASIFICATION)

H77 22039 STATUS OF THE STEAM-IRON PROGRAM

Tarman, P.B., (Institute of Gas Technology, Chicago, IL), 17 p., 1975, (Contract E(49-18)-2435), CONF-7510149-3, From 7th synthetic pipeline gas symposium; Chicago, IL, Oct 27, 1975

The pilot plant design and construction are discussed. Supporting studies carried out include tests to establish the operating conditions necessary for non-agglomerating, fluidized bed reducing gas production. Slurry pumping tests were made to establish the operating ranges of the char-water slurry feed system. Computer studies were made to establish the operating range of the combined producer and steam-iron reactor system. A program was begun to evaluate other chars for use in the pilot plant and to develop iron solids for future operation of the process.

(COAL CHAR, PILOT PLANT DESIGN, FLUIDIZED BED REDUCTION, FUEL GAS PRODUCTION)

H77 22040 STATUS OF THE STEAM-IRON PROGRAM

Tarman, P.B., Punwani, D.V., (Institute of Gas Technology, Chicago, IL), 11 p., 1976, (Contract E(49-18)-2435), CONF-761064-5, From 8th synthetic pipeline gas symposium; Chicago, IL, Oct 18, 1976

Construction of the pilot plant began in September 1975; mechanical completion was achieved in July 1976. Erection of the reactors and of the steel deckwork around them was completed in March 1976. During the latter stages of plant construction, efforts were concentrated on commissioning of the peripheral systems. The slurry vaporizer has been tested, and although tests of longer duration will be necessary and more concentrated slurries will have to be vaporized, it is believed that the principle of high-pressure slurry vaporization was demonstrated. The internal refractory lining has been cured. Several support programs are underway. The kinetic studies program is to develop improved iron solids for use in the steam-iron process. Sixty-seven attrition tests and 56 reactivity tests have been made on a variety of catalysts and support materials. Twenty-six tests were conducted with a Western Kentucky bituminous coal char.

(COAL CHAR, FLUIDIZED BED REDUCTION, CATALYST TESTING)

H77 22041 LIQUID PHASE METHANATION QUARTERLY REPORT, APRIL 1, 1976-JUNE 30, 1976

Anon, (Chem Systems, Inc., New York, NY), 75 p., June 30, 1976, FE-1505-8

All chemical and physical property analyses were completed on the polishing reactor catalyst (CRG-A) samples. All four 1000-hr-duration runs indicated a constant reactor performance throughout. Operations in the large-scale PDU continued through April. Synthesis feed gases having a H sub 2/CO molar ratio of 1.02 and 1.40 were investigated with and without the direct injection of steam. The effluent gas composition was monitored and found to be consistent in all respects with results obtained in the smaller bench-scale unit. Negotiations were finalized on completing the LPM pilot plant. A detailed evaluation of the LPM/S process was completed. The economics of the LPM/S process were developed for two typical cases. Process flowsheets, heat and material balances and equipment specifications were prepared for both cases for a commercial-sized plant producing 250 MMM BTU/D of SNG. The results of the process evaluation demonstrate the economic attractiveness of the LPM/S process in commercial-sized SNG complexes.

(METHANATION, LIQUID PHASES, COAL GASIFICATION)

H77 22042 ENERGY RESOURCES REPORT

Frank, A.L., V5:299, N30, July 29, 1977

Air Products and Chemicals, Inc., Allentown, PA., has been selected to negotiate with Energy Research and Development Administration for the design, construction and operation of a facility to produce hydrogen from gasification of coal for use in industrial processes. Located at Cedar Bayou, TX, near Baytown, the hydrogen from coal facility will convert 1,210 tons of Texas lignite into 29.5-million cu. ft. of hydrogen and 7 mmcf of carbon monoxide per day. Operation of the plant, estimated to cost $95-to $125-million, could begin in 1981 and run for 15 years or more. As explained by ERDA, two Koppers-Totzek gasifiers, a type on the market for 20-25 years, will use dried lignite ground to fine particles. This will be blown into the gasifiers with steam and oxygen under atmospheric pressure. Temperatures reaching almost 3,500^{o}F are achieved in producing the gaseous products. Product hydrogen will have a purity of 99% or more.

(COAL GASIFICATION, NEGOTIATIONS, FUTURE FACILITY)

H77 22226 ENVIRONMENTAL CONSIDERATIONS OF SELECTED ENERGY CONSERVING MANUFACTURING PROCESS OPTIONS: VOLUME IV PETROLEUM

Anon, (Little, Arthur D., Inc., Cambridge, MA), 193 p., Dec 1976, EPA/600/7-76/034d, PB-264 270/OWE

This study assesses the likelihood of new process technology and new practices being introduced by energy intensive industries and explores the environmental impact of such changes. Volume 4 deals with the petroleum refining industry and examines five options: (1) direct combustion of asphalt in process heaters and boilers, (2) hydrocracking of vacuum bottoms, (3) flexicoking of vacuum bottoms, (4) internal electrical power generation, (5) hydrogen generation by partial oxidation, all in terms of process economics and environmental/energy consequences.

(TECHNOLOGY ASSESSMENT, ENVIRONMENTAL IMPACT, PARTIAL OXIDATION)

H77 22652 SUPPLY OF LIQUEFIED NATURAL GAS TO THE NORTHEAST

Bray, G.R., Julin, S.K., Simmons, J.A., (Brookhaven National Lab., Upton, NY), 103 p., Apr 1976, BNL-50556

The following aspects of the supply for liquefied natural gas to the northeastern part of the U.S. are discussed: major facilities and equipment; institutional considerations and environmental impacts; site selection criteria; time required to implement an LNG project; projected availability and reliability of supply; projection of future imports to the northeast region; cost projections; and secondary benefits.

(LNG PROJECT, NATURAL GAS SUPPLY)

H77 23035 METHOD OF PRODUCING GAS MIXTURES CONTAINING MAINLY H_2 AND CO BY NON-CATALYTIC PARTIAL-OXIDATION OF A HC-CONTAINING FUEL WITH A GAS CONTAINING FREE OXYGEN IN THE REACTION ZONE OF AN UNHINDERED-FLOW GAS GENERATOR

Crouch, W.B., (Texaco Development Corp., New York, NY), German Patent 2,450,961/A, 14 p., 1 tab, May 6, 1976, In German

The production of the gas mixtures mainly containing H_2 and CO takes place in an unhindered-flow gas generator at an autogenic temperature of about 816°C to 1,927°C and at a pressure of about 1 to 350 atmospheres. The partial oxidation is performed in the presence of a temperature moderator (NH_3), where the NH_3 is added together with the hydrocarbon-containing fuel into the reaction zone. The NH_3 may be introduced in liquid form or as a gas. The oxygen-containing gas is air, oxygen-enriched air or pure oxygen. The hydrocarbon-containing fuel can be used in the following state: a) liquid hydrocarbons; b) gaseous hydrocarbons; c) oxidized organic hydrocarbon-containing materials; d) pumpable slurries of solid, hydrocarbon-containing fuels. The fuels are heated to 649°C before being introduced into the reaction zone. The temperature must be below the cracking temperature.

(HYDROCARBON OXIDATION, GAS GENERATION)

H77 23036 DEEP SPACE MATERIAL SOURCES - FROM ASTEROIDS FOR SPACE COLONIES

Drexler, K.E., (MIT, Cambridge, MA), American Institute of Aeronautics and Astronautics, Inc., New York, NY, p. 29, 30, 1977, In Space Manufacturing Facilities Space Colonies; Proceedings of The Princeton Conference, Princeton, NJ, May 7-9, 1975, Discussion, p. 30, 31, A77-35801 16-22, A77-35805

Three ways of using materials present in the asteroid belt to advantage for the local support of deep-space colonies are discussed. Asteroids are judged equivalent "in virtually all respects" as a resource base to the earth. Energy, metals and organic materials necessary to support and develop colonies are available; hydrogen and water resources, about one-half the organic materials content of terrestrial oil shale, and iron can be acquired. Iron is judged present in large chunks (many KM in diameter) down to fine dust; it is viewed as strong, tough, ductile, corrosion-resistant, containing approximately 5% nickel and "for engineering purposes...superior to most of the steel produced on ...earth." Estimates are offered for capital costs, materials transportation costs, processing costs, and a thousand 100 megaton H-bombs for processing.

(ASTEROIDS, HYDROGEN RESOURCES, COST ESTIMATES)

<u>H77 23037</u> METHOD FOR THE GENERATION OF HYDROGEN

Hohne, K., U.S. Patent 3,985,865, 4 p., Oct 12, 1976, to Siemens Aktiengesellschaft, Priority date May 3, 1974, Federal Republic of Germany

The invention provides a method for the generation of hydrogen, particularly for the generation of hydrogen for fuel cells. The hydrogen is generated through reaction of magnesium or a magnesium-aluminum mixture with water in the presence of at least one cobalt oxide and at least one water-soluble chloride, there being additionally admixed to the reaction mixture a molybdenum compound, particularly a molybdenum oxide or a molybdenate.

(CHEMICAL REACTORS, MAGNESIUM, COBALT OXIDE, MOLYBDENUM OXIDE)

<u>H77 23038</u> METHOD OF HYDROGEN PRODUCTION

Schulten, R., Teggers, H., Schulze-Bentrop, R., German Patent 2,409,762/A, 5 p., 1 fig., Oct 9, 1975, to Rheinische Braunkohlenwerke A.G., In German

This method of producing hydrogen from water in a multistage cycle process works without inorganic salts and requires only gases and liquids. Carbon oxide is catalytically converted into carbon dioxide and water by means of water vapor. The carbon dioxide is then converted into sulfuric acid and carbon oxide using water and sulfur dioxide at high temperatures and pressures, and the sulfuric acid is separated into sulfur dioxide, oxygen and water via the intermediate SO_2. The SO_2 and CO_2 thus obtained are led back into the appropriate reaction stages and hydrogen and oxygen are removed from the process as end products. (A schematic flow diagram is given).

(SULFURIC ACID CONVERSION, CARBON OXIDE, SULFUR DIOXIDE)

<u>H77 23218</u> FAST PRODUCTION OF METHANE BY ANAEROBIC DIGESTION PROGRESS REPORT, SEPTEMBER 24, 1976-OCTOBER 24, 1976

Finney, C.D., Evans, R.S. II, Finney, K.A., (Natural Dynamics, Des Moines, IA), 6 p., Nov 1976, (Contract EY-76-C-02-2900), COO-2900-6
NTIS $3.50

Three modified five (5) liter standard baffled digesters are constructed and are being loaded with a stock of thermophilic bacteria. Individual digesters will be acclimated at 48, 53 and 58°C at 760 mm mercury absolute for the purpose of determining the effect of temperature on glucose loading rates. During the equilibration period the relative concentrations of acetic, propionic and butyric acids will be determined in order to monitor any changes in bacterial populations.

(ANAEROBIC DIGESTION, GLUCOSE, BACTERIA)

H77 23219 AN INQUIRY INTO BIOPHOTOLYSIS OF WATER TO PRODUCE HYDROGEN

Lien, S., San Pietro, A., (Indiana Univ. at Bloomington, Dept. of Plant Sciences), 58 p., 1976, NSF/RA-760417, PB-263 680/1WE

This report is intended to serve as an assessment of solar energy. It is concerned with the photoconversion apparatus of green plants that serves to convert absorbed solar energy into chemical free energy and thereby provides a non-polluting energy source-gaseous hydrogen. This process is the biophotolysis of water to yield hydrogen (and oxygen). Relevant information available in the literature is presented under three main topics: (1) Energy Efficiency of Biophotolysis of Water includes a discussion of the theoretical maximal energy conversion efficiency of PETS (Photosynthetic Electron Transport System) and a departure from theoretical maximal efficiency; (2) Stability of PETS includes a discussion of photochemical degradation of PETS-photoinhibition and photo-oxidation, inactivation of PETS, and stabilization of PETS in vitro; and (3) Hydrogenase includes a discussion of the occurrence and general properties of hydrogenase, photoproduction of hydrogen, the oxygen sensitivity of hydrogenase and the preparation and stabilization of hydrogenase.

(BIOPHOTOLYSIS, PHOTOCONVERSION)

H77 23220 LONG-RANGE CONCEPTS: APPLICATIONS OF PHOTOSYNTHETIC HYDROGEN PRODUCTION AND NITROGEN FIXATION RESEARCH

Mitsui, A., (Univ. of Miami, FL), p. 653-672, 1976, In Capturing the Sun through Bioconversion, Washington Center, Washington, DC, Mar 10, 1976, CONF-760354

The use of the ability of marine photosynthetic organisms to produce hydrogen and fix introgen is discussed from the following aspects: fuel production, food production, advantages of the photosynthetic system of marine microorganisms, the problem of solar energy bioconversion efficiency and approaches to solving the bioconversion efficiency problem.

(BIOCONVERSION, EFFICIENCY TESTING, MARINE MICROORGANISMS)

H77 23441 PERMEATION AND GETTERING OF HYDROGEN ISOTOPES FOR CTR APPLICATIONS

Swansiger, W.A., Swisher, J.H., West, L. A., Perkins, W.G., (Sandia Labs., Livermore, CA), 56 p., Apr 1974, SLL-74-0003

The proposed program is directed toward providing the necessary tritium permeation and other related materials data for the components of the reactor that will be directly associated with the containment and recovery of hydrogen isotopes. These components are: (1) First wall materials, which are selected primarily for high-temperature strength and resistance to ion implantation damage. (2) Heat exchanger hardware for steam turbines. (3) Divertors, which remove unburned D-T gas from the plasma for recycling.

(HYDROGEN ISOTOPES, RECOVERY, CONTAINMENT, REACTOR MATERIALS)

H77 23639 IMPROVED SOLAR ENERGY CONVERSION EFFICIENCIES FOR THE PHOTOCATALYTIC PRODUCTION OF HYDROGEN VIA TiO_2 SEMICONDUCTOR ELECTRODES

Houlihan, J.F., Madacsi, D.P., Walsh, E.J., Mulay, L.N., (Pennsylvania State Univ., Sharon, PA), Mater. Res. Bull, V11:1191-1198, N9, Sept 1976

Overall solar energy conversion efficiencies of at least 0.8 percent, somewhat greater than those previously reported, have been obtained in the photocatalytic production of hydrogen using TiO_2 semiconductor electrodes prepared by heat treatment of titanium metal foils. A shift in the threshold frequency for hydrogen evolution toward energies slightly lower than the 3.02 eV bandgap of TiO_2 was observed for some of these electrodes. This result supports the possibility of utilizing a greater portion of the solar spectrum, thereby increasing overall conversion efficiency even further. A tentative explanation of this shift involves the presence of mixed phases of the titanium-oxygen system (Magneli phases) in the semiconducting film.

(PHOTOCATALYSIS, TITANIUM OXIDE, SOLAR ENERGY CONVERSION)

III. UTILIZATION

H77 30076 PERFORMANCE CHARACTERISTICS OF TURBO-ROCKETS AND TURBO-RAMJETS USING HIGH ENERGY FUEL

Dini, D., (Pisa Univ., Italy), In Agard Variable Geometry and Multicycle Eng., 30 p., N77-22112 13-07, N77-22131
Avail:NTIS

The aerodynamic and thermodynamic behavior of turborockets and turboramjets is considered. By means of variable engine geometry, multicycle engines meet aircraft requirements for take-off, climb, cruise, maneuver, loiter, and landing. Performance characteristics are evaluated for these conditions, taking into account variable geometry in some intake and exhaust configurations. Problems arising from future high energy fuels, particularly hydrogen, impose changes in interface components, geometry and control. Preliminary designs of turborockets and turboramjets for military and civil applications are discussed.

(AERODYNAMIC CHARACTERISTICS, ROCKET DESIGN, APPLICATION)

H77 30077 AEROSPIKE THRUST CHAMBER PROGRAM--CUMULATIVE DAMAGE AND MAINTENANCE OF STRUCTURAL MEMBERS IN HYDROGEN OXYGEN ENGINES FINAL REPORT

Campbell, J. Jr., Cobb, S.M., (Rocketdyne, Canoga Park, CA), NASA-CR-135169, 167 p., R76-189, NAS3-20076, N77-21189
Avail:NTIS

An existing, but damaged, 25,000-pound thrust, flightwieght, oxygen/hydrogen aerospike rocket thrust chamber was disassembled and partially repaired. A description is presented of the aerospike chamber configuration and of the damage it had suffered. Techniques for aerospike thrust chamber repair were developed, and are described, covering repair procedures for lightweight tubular nozzles, titanium thrust structures, and copper channel combustors. Effort was terminated prior to completion of the repairs and conduct of a planned hot fire test program when it was found that the copper alloy walls of many of the thrust chamber's 24 combustors had been degraded in strength and ductility during the initial fabrication of the thrust chamber. The degradation is discussed and traced to a reaction between oxygen and/or oxides diffused into the copper alloy during fabrication processes and the hydrogen utilized as a brazing furnace atmosphere during the initial assembly operation on many of the combustors. The effects of the H_2/O_2 reaction within the copper alloy are described.

(ENGINE DAMAGE, ENGINE MAINTENANCE, AEROSPIKE THRUST CHAMBER)

H77 30078 BURNER II INTERIM UPPER STAGE--FOR USE WITH SPACE SHUTTLE

Kudish, H., (Boeing Aerospace Co., Seattle, WA), American Astronautical Society, San Diego, CA, AAS 75-170, p. 715-718, 1977, In Space Shuttle Missions of the 80's; Proceedings of the Twenty-first Annual Meeting, Denver, CO, Aug 26-28, 1975, Part 2, A77-36526 16-12, A77-36547

IUS vehicles based on Burner II design are described. The expendable vehicle consists of a forward stage with a 4700-LB solid-propellant motor and an aft stage with an interstage, a 20,000-LB solid-propellant motor, and an aft skirt structure. The avionics, telemetry, tracking and command system, thrust vector control, hydrazine-fueled reaction control system, guidance and control, inertial navigation system and electrical power system are examined.

(ROCKET ENGINE DESIGN, SPACE SHUTTLE BOOSTERS, SOLID PORPELLANT ROCKET ENGINES)

H77 30079 ADVANCED TECHNOLOGY AND FUTURE EARTH-ORBIT TRANSPORTATION SYSTEMS

Henry, B.Z., Eldred, C.H., (NASA, Langley Research Center, Vehicle Analysis Branch, Hampton, VA), American Institute of Aeronautics and Astronautics and Princeton University, Conference on Space Manufacturing Facilities, 3rd, Princeton, NJ, AIAA Paper 77-530, 10 p., May 9-12, 1977, A77-32055

The paper is concerned with the identification and evaluation of technology developments which offer potential for high return on investment when applied to advanced transportation systems. These procedures are applied in a study of winged single-state-to-orbit (SSTO) vehicles, which are considered feasible by the 1990's. Advanced technology is considered a key element in achieving improved economics, and near term investment in selected technology areas is recommended.

(FUTURE TRANSPORTATION, SPACECRAFT DESIGN, TECHNOLOGY DEVELOPMENTS)

H77 30080 PROGRAM DOCUMENTATION FOR ELAPSED TIME TO OXYGEN AND HYDROGEN CAUTION AND WARNING SYSTEM FOR CAPTIVE/ ACTIVE 1 AND 3 FLIGHTS

Hurst, J.E., (Lockheed Electronics Co., Houston, TX, Systems and Services Div.), NASA-CR-151339, 8 p., LEC-10443, JSC-12618, NAS9-15200, N77-23187
Avail:NTIS

High pressure gas storage simulation runs were made to compute the elapsed time from T-0 disconnect (transfer to onboard reactant) to the caution and warning pressures for the primary oxygen (O_2) and hydrogen (H_2) systems of orbiter vehicle (OV) 101. The simulation runs were made for approach and landing test flights captive/active 1 and captive/active 3.

(GAS STORAGE SIMULATION, ORBITER VEHICLE FLIGHT TESTS)

H77 30081 LASER-HEATED ROCKET THRUSTER FINAL REPORT JUNE 1975-JUNE 1976

Shoji, J.M., (Rocketdyne, Canoga Park, CA), NASA-CR-135128, 187 p., R76-104, NAS3-19728, N77-24188
Avail:NTIS

A space vehicle application using 5,000-kw input laser power was conceptually evaluated. A detailed design evaluation of a 10-kw experimental thruster including plasma size, chamber size, cooling and performance analyses, was performed for 50 PSIA chamber pressure and using hydrogen as a propellant. The 10-kw hardware fabricated included a water cooled chamber, an uncooled copper chamber, an injector, igniters and a thrust stand. A 10-kw optical train was designed.

(PLASMA PROPELLANT, LASER HEATING, HYDROGEN FUELS)

H77 30082 ALTERNATE TUG/IUS APPROACHES--INTERIM UPPER STAGE FOR SPACE SHUTTLE

Tischler, A.O., American Astronautical Society, San Diego, CA, AAS 75-140, p. 611-622, 1977, In Space Shuttle Missions of the 80's; Proceedings of the Twenty-first Annual Meeting, Denver, CO, Aug 26-28, 1975, Part 2, A77-36526 16-22, A77-36546

Operating, economic and schedule objectives for the shuttle upper stage are reviewed, and the performance and cost characteristics of upper stage candidates are discussed. It is concluded that a new tow-stage, solid-motor IUS, with a mass of about 26,500 pounds is the most cost effective approach to IUS requirements. In addition, a hydrogen-oxygen stage, with a mass of about 22,500 pounds and used with a booster stage comprising two perigee burn motors of the IUS, completes a payload deployment/recovery/replacement system which is compatible with schedule constraints imposed by space program funding limitations.

(ECONOMICS, HYDROGEN OXYGEN ENGINES, SPACE SHUTTLE)

H77 30083 NEAR-TERM CHEMICALLY-PROPELLED SPACE TRANSPORT SYSTEMS--TO SPACE COLONIES

Tischler, A.O., American Institute of Aeronautics and Astronautics, Inc., New York, NY, p. 71-75, 1977, In Space Manufacturing Facilities Space Colonies; Proceedings of the Princeton Conference, Princeton, NJ, May 7-9, 1975, Discussion p. 75-76, A77-35801 16-12, A77-35810

Energy requirements and maneuver calculations for launching and conveying required loads from earth to L5 libration point, and from Low Earth Orbit (LOE) to a Lunar Parking Orbit (LPO) or to the lunar surface, are discussed. Data referable to placing 50,000 tons and 10,000 persons at L5 or in LOE and to delivery of 200 persons and 3000 tons to the lunar surface, are presented and tabulated. Deployable-retrievable hydrogen-oxygen chemical propulsion systems (single-stage or two-stage) and a schedule for modular delivery of shuttle loads to LOE are discussed.

(PROPULSION SYSTEM, HYDROGEN OXYGEN ENGINE, SPACE TRANSPORTATION, ENERGY REQUIREMENTS)

H77 31046 MINIMUM ENERGY, LIQUID HYDROGEN SUPERSONIC CRUISE VEHICLE STUDY FINAL REPORT APR 21-OCT 17, 1975

Brewer, G.D., Morris, R.E., (Lockheed-California Co., Burbank, CA), NASA-CR-137776, LR-27347, 178 p., Oct 1975, (Contract NAS2-8781), N76-17101
NTIS $7.50

The potential was examined of hydrogen-fueled supersonic vehicles designed for cruise at Mach 2.7 and a Mach 2.2. The aerodynamic, weight and propulsion characteristics of a previously established design of a LH_2 fueled, Mach 2.7 supersonic cruise vehicle (SCV) were critically reviewed and updated. The design of a Mach 2.2 SCV was established on a corresponding basis. These baseline designs were then studied to determine the potential of minimizing energy expenditure in performing their design mission, and to explore the effect of fuel price and noise restriction on their design and operating performance. The baseline designs of LH_2 fueled aircraft were then compared with equivalent designs of jet A (conventional hydrocarbon) fueled SCV's. Use of liquid hydrogen for fuel for the subject aircraft provides significant advantages in performance, cost, noise, pollution, sonic boom and energy utilization.

(SUPERSONIC AIRCRAFT, PROPULSION, DESIGN ANALYSIS)

H77 32074 A COMPARISON OF OPERATIONAL ECONOMICS OF TRANSPORTATION VEHICLES OPERATED ON GASOLINE AND COAL-GENERATED HYDROGEN

Billings, R.E., (Billings Energy Research Corp., Provo, UT), Marcel Dekker, Inc., New York, NY, p. 397-417, 1977, In Synthetic Fuels Processing Comparative Economics; Proceedings of the Symposium, New York, NY, Apr 4-9, 1976, A77-36326 16-44, A77-36343

An investigation is conducted concerning the vehicle operational costs for a 350-vehicle taxi fleet and a 100-vehicle bus fleet. The historical background regarding hydrogen engines is reviewed. Problems of hydrogen storage are examined, taking into account the possibility to make use of metal hydrides. Attention is given to engine efficiency, aspects of air pollution, the efficiency of existing energy resource utilization, economics, and safety. The investigation shows that coal-generated hydrogen does have potential as a vehicular fuel for transportation. The best area for early implementation of the fuel is in fleet vehicles.

(ECONOMICS, VEHICLE OPERATION COST, VEHICULAR FUEL)

H77 32075 DEVELOPMENTAL TRENDS OF HYDROGEN VEHICLES USING HYDRIDE STORAGE TANKS

Buchner, H., Saeufferer, H., 21 p., 1976, ERDA-tr-238, Translation of German report

The utilization of hydrogen-driven vehicles was not practical until quite recently owing to the voluminous, dangerous and energy-consuming hydrogen storage in gaseous or liquid form. Only owing to the development of suitable metallic hydride storage tanks, i.e., with the help of alloys in which gaseous hydrogen is bound metallically in the lattice, does hydrogen propulsion make gains chiefly under the viewpoints of sparing petroleum reserves and its rising significance with respect to environmental pollution. For the last two years, hydrogen propulsion has been tested in connection with hydride storage tanks at Daimler-Benz in practical operation with small transport vehicles. A discussion is given of the Mercedes-Benz experimental hydride vehicle and the refueling of the tank with gaseous hydrogen.

(METAL HYDRIDE STORAGE, TRANSPORT VEHICLES)

H77 32076 HYDROGEN ENRICHMENT FOR AUTOMOBILES

Cotrill, H., p. 134-143, 1976, ERDA-76-136, From Highway vehicle systems contractors coordination meeting; Ann Arbor, MI, May 1976

In Highway vehicle systems contractors coordination meeting. Tenth summary report. The system under development has the potential of meeting the stringent 0.4 gram per mile NOx standard, while at the same time significantly improving fuel economy. The concept uses hydrogen to extend the lean flammability limit of gasoline and thus permit combustion of the mixture to proceed at ultra-lean conditions. Combustion at these ultra-lean conditions improves the vehicle fuel economy as a result of improvements in the engine thermal efficiency. The test vehicle, run on a chassis dynamometer, is a modified 1973 Chevrolet Impala with a 350 cu in. engine. The tests show that with the exception of the hydrocarbon performance the 1978 standards are readily met by hydrogen enrichment. The fuel economy results of 13.7 mpg represent a 23 percent improvement over the stock 1973 vehicle and a 13 percent mileage improvement over a 1975 vehicle. In addition, it can be concluded that the two level generator flow rate strategy is completely adequate.

(NOx EMISSION, HYDROGEN ENRICHMENT, GAS MIXTURES)

H77 32077 HYDROGEN-ENRICHMENT-CONCEPT PRELIMINARY EVALUATION FINAL REPORT

Ecklund, E., (Jet Propulsion Lab., CA, Inst. of Tech., Pasadena, CA), NASA-CR-152814, 221 p., JPL-1200-237 TEC-75/007, N77-22290 Avail:NTIS

A hydrogen-enriched fuels concept for automobiles is described and evaluated in terms of fuel consumption and engine exhaust emissions through multicylinder (V-8) automotive engine/hydrogen generator tests, single cylinder research engine (CFR) tests, and hydrogen-generator characterization tests. Analytical predictions are made of the fuel consumption and no/sub x/emissions which would result from anticipated engine improvements. The hydrogen-gas generator, which was tested to quantify its thermodynamic input-output relationships was used for integrated testing of the V-8 engine and generator.

(HYDROGEN ENRICHMENT, FUEL CONSUMPTION, EXHAUST EMISSIONS)

H77 32078 METHOD AND DEVICE FOR THE PRODUCTION OF GASES RICH IN HYDROGEN

Houseman, J., Rupe, J.H., Kushida, R.O., German Patent 2,439,873/A, 21 p., 5 figs., Mar. 13, 1975, to NASA, In German

Gases rich in hydrogen for driving motor vehicle engines can be produced by injecting water into a mixture of air and hydrocarbon fuel, at the ignition of which very hot combustion gases have resulted through partial oxidation, where-by the water is transformed into steam by the hot gases. After injection of additional hydrocarbon fuel, the gas rich in hydrogen forms by steam fission. Several types of such a hydrogen generator, which is compact and suitable for passenger cars, are described. Pre-heating of the gases and the transmission of them as well as devices for the sensing of the temperatures are intended to assure the right moment for the injections. The complicated design and construction necessary until now for hydrogen generators is eliminated because a partial oxidation process is used to generate the energy which is required for the steam fission reaction.

(STEAM FISSION, HYDROGEN GENERATOR, PARTIAL OXIDATION)

H77 33083 PREMIXED FLAME PROPAGATION CHARACTERISTICS IN A SUPERSONIC AIRSTREAM

Agnone, A.M., (New York University, Westbury, NY), Anderson, G.Y., (NASA, Langley Research Center, Hypersonic Propulsion Branch, Hampton, VA), AIAA Journal, V15:749-751, May 1977

Measured values of flame angles are presented to aid the design of premixed combustion chambers and preduction of flame propagation. Flame spread, velocity, and dependence of burning rate on the properties of unburned flow and on turbulence levels are compared with the measured values. The premixed flame angle is found proportional to the amount of heat released, and correlates readily with the fuel mixture ratio through the rate of heat release or rate of water formation. Finite rate combustion affects flame angle mostly at off-stoichiometric conditions. The pilot affects the flame angle if abundant unburnt fuel is present in the pilot hot gases. Viscosity runs several times over the rated level.

(FLAME PROPAGATION, SUPERSONIC AIRSTREAM, COMBUSTIBLE FLOW)

H77 33084 SECONDARY GROWTH OF BASE PRESSURE DURING THE COMBUSTION BEHIND AN AXISYMMETRIC BODY IN A SUPERSONIC FLOW

Baev, V.K., Vuititskii, S.A., Garanin, A.F., Tretiakov, P.K., Iasakov, V.A., (Akademiia Nauk SSSR, Institut Teoreticheskoi I Prikladnoi Mekhaniki, Novosibirsk, USSR), Fizika Goreniia I Vzryva, V13:125-129, Jan-Feb 1977, A77-32312, In Russian

The effect of hydrogen combustion on the base pressure behind an axisymmetric body was studied in a supersonic wind tunnel at Mach numbers of 2 and 2.5. It was shown that heat release behind the body can lead to a secondary increase of base pressure, while an increase in the drag of the tunnel leads to a secondary increase of base pressure with less heat release.

(COMBUSTION CHARACTERISTICS, BASE PRESSURE, WIND TUNNEL TESTS)

H77 33085 THE TRANSITION TO INSTABILITY IN A STEADY HYDROGEN-OXYGEN DIFFUSION FLAME

Dongworth, M.R., Melvin, A., (British Gas Corp., London, England), Combustion Science and Technology, V14:177-182, Nov 1976, A77-24972

Blow-off of a streamwise diffusion flame does not usually show features intermediate between those characteristic of the burner-attached flame and a quasi-stable lifted flame. The present work has, however, characterized an unusual intermediate stage in the blow-off of a lean hydrogen-oxygen diffusion flame, where the flame base takes on a stable cellular structure. From previous work, it is known that, near extinction, there is transfer of fuel through the base of the flame into the oxidant stream. The partial premixing resulting from such interstream transfer gives rise in the particular case of this lean flame to a composite premixed/diffusion flame structure at the flame base which is most probably responsible for the cellularity.

(DIFFUSION FLAME, FLAME PROPAGATION, COMBUSTION CHAMBERS)

H77 33086 THE NOX EMISSION LEVELS OF UNCONVENTIONAL FUELS FOR GAS TURBINES

Hung, W.S.Y., (Westinghouse Electric Corp., Generation Systems Div., Philadelphia, PA), American Society of Mechanical Engineers, ASME Paper 77-GT-16, 5 p., Mar 27-31, 1977, Gas Turbine Conference and Products Show, Philadelphia, PA, A77-28535

An experimentally verified NOx emission model for gas turbines has been reported previously. The model has been modified to determine the NOx emission levels of various fuels as compared with No. 2 distillate oil. The NOx emission levels of various conventional and unconventional gas-turbine fuels of interest are predicted. The predicted NOx emission levels for these fuels, including methanol, ethanol, propane, and hydrogen, are in good agreement with available laboratory and field data from stationary, aircraft and automotive gas-turbine combustors. The predicted results should be applicable to other fuel-lean heterogeneous combustion systems.

(NOX EMISSION, EMISSION MODEL, COMBUSTION EMISSION)

H77 33087 NITRIC OXIDE FORMATION FROM FUEL AND ATMOSPHERIC NITROGEN

Leonard, P.A., Plee, S.L., Mellor, A.M., (Purdue University, West Lafayette, IN), Combustion Science and Technology, V14:183-193, Nov 1976, DAAE07-73-C-0095, Research supported by the General Motors Corp., A77-24973

The thermal no formation rates preducted by the H_2/O_2 partial-equilibrium technique are compared with the Soete's (1973) overall rates and with data obtained in lean and rich laminar undoped CH_4/air and C_3H_8/air flames stabilized on a flat burner at equivalence ratios of 0.8 and 1.25. It is found that the H_2/O_2 technique predicts thermal formation rates in the postflame region that are within the experimental errors for the flames examined and that the region of maximum thermal no formation occurs behind the flame. De Soete's overall expression is shown to predict fuel no formation rates to within a factor of 10 for an ammonia-doped CH_4/air flame. It is suggested that the nitrogen intermediate postulated by De Soete for fuel no formation is HCN and that the no-forming step is CN + O_2 yields CO + NO.

(COMBUSTION PRODUCTS, ENVIRONMENTAL EFFECTS, REACTION KINETICS)

H77 33088 COMBUSTION OF HYDROGEN INJECTED INTO A SUPERSONIC AIRSTREAM (THE SHIP COMPUTER PROGRAM) FINAL REPORT

Markatos, N.C., Spalding, D.B., Tatchell, D.G., (Fluid Mechanics and Thermal System, Inc., Waverly, AL), NASA-CR-2802, 127 p., NAS1-14301, N77-21363
Avail:NTIS

The mathematical and physical basis of the ship computer program which embodies a finite-difference, implicit numerical procedure for the computation of hydrogen injected into a supersonic airstream at an angle ranging from normal to parallel to the airstream main flow direction is described. The physical hypotheses built into the program include a two-equation turbulence model, and a chemical equilibrium model for the hydrogen-oxygen reaction. Typical results for equilibrium combustion are presented and exhibit qualitatively plausible behavior. The computer time required for a given case is approximately 1 minute on a CDC 7600 machine. A discussion of the assumption of parabolic flow in the injection region is given which suggests that improvement in calculation in this region could be obtained by use of the partially parabolic procedure of pratap and spalding. It is concluded that the technique described herein provides the basis for an efficient and reliable means for predicting the effects of hydrogen injection into supersonic airstreams and of its subsequent combustion.

(COMPUTER PROGRAMS, INJECTION, SUPERSONIC COMBUSTION)

H77 33089 CALCULATION OF CONDITIONS FOR COMBUSTION SEPARATION BEHIND A FLAT PROJECTION AND IN A RECESS IN THE SUPERSONIC FLOW OF A HYDROGEN-AIR FUEL MIXTURE

Meshcheriakov, E.A., Makasheva, O.V., (Tsentral'nyi Aerogidrodinamicheskii Institut, Moscow, USSR), Fizika Goreniia I Vzryva, V12:871-879, Nov-Dec 1976, A77-25881, In Russian

Theory of isothermal reactors in combination with elements of theory of turbulent jets is applied to calculate the flow parameters in separated combustion in the recirculation zones behind a flat projection and in a recess situated in the supersonic flow of a homogeneous hydrogen-air fuel mixture. Fairly complete kinetics of hydrogen combustion in air is used in the calculations, including eight reactions for seven components. By the method it is possible to trace the effect of various geometric and regime parameters on the stability limits of the operation of combustion stabilizers of a given type.

(FLOW PARAMETERS, SUPERSONIC FLOW, REACTION KINETICS)

H77 33090 EXPERIMENTAL INVESTIGATION AND NUMERICAL CALCULATION OF A LAMINAR AXISYMMETRIC HYDROGEN-OXYGEN DIFFUSION FLAME

Roertgen, H.G., (Rheinisch-Westfaelische Technische Hochschule, Aachen, West Germany), Waerme- Und Stoffuebertragung, V10:33-50, N1, 1977, A77-28120, In German

A description is given of results that were obtained in a research program which is concerned with the development of models for laminar free jet diffusion flames. The results considered include the distributions of the temperature, the velocity and the concentrations of the chemical components in a laminar hydrogen-oxygen diffusion flame maintained at atmospheric pressure. Velocity measurements were conducted with a laser-doppler anemometer. Concentrations of the stable chemical components H_2, O_2 and H_2O were determined by analyzing with a mass spectrometer gas samples obtained with the air of a water-cooled microprobe. The temperature measurements were carried out with spectroscopic techniques and by means of thermoelements. Attention is also given to the system of differential equations for the model of the free jet diffusion flame, the numerical integration of the equation system, and a comparison of the computed data with the experimental values.

(LAMINAR FLOW, CHEMICAL COMPONENTS, DIFFERENTIAL EQUATIONS)

H77 33091 RATE COEFFICIENT FOR $H + O_2 + M = HO_2 + M$ EVALUATED FROM SHOCK TUBE MEASUREMENTS OF INDUCTION TIMES

Slack, M.W., (Grumman Aerospace Corp., Bethpage, NY), Combustion and Flame, V28:241-249, N3, 1977

Shock tube experiments measured hydrogen-air induction times near the second explosion limit. By matching these experimental results with numerically predicted induction times, the rate coefficient for the reaction $H + O_2 + M = HO_2 + M$ was evaluated as K-Sub 4,N_2 = 3.3 (+ - .6) x 10 to the 15 cm to the 6th/sq mole/s.

(REACTION KINETICS, SHOCK TUBE EXPERIMENTS, HYDROGEN OXYGEN ENGINES)

H77 33092 STUDIES ON REALIZATION OF NORMAL COMBUSTION OF HYDROGEN IN SPARK-IGNITION ENGINES BY REDUCTION OF TEMPERATURE OF RESIDUAL BURNT GASES

Vasilescu, C.A., Ianovici, I., Soiman, M., Revue Roumaine Des Sciences Techniques, Serie Electrotechnique Et Energetique, V22:135-145, Jan-Mar 1977, A77-28050, In French

The possibility of avoiding ignition by hot residual gases upon admission of air-hydrogen fuel mixture in a spark-ignition engine was investigated theoretically and experimentally. One possibility studied is the reduction of the gas temperature in the cylinder by introducing air. The effect of fuel composition as cooling gas and the influence of recirculated burnt gases as moderators of the chemical reactions are studied. Results from an experimental motor are used to investigate these effects. The study shows the advantage of high compression ratios and the effectiveness of cooling the residual gases by introducing air in the cylinder before admitting fresh fuel mixture.

(AIR-HYDROGEN FUEL, INTERNAL COMBUSTION ENGINE, CHEMICAL REACTIONS)

H77 34272 HIGH POWER DENSITY FUEL CELL FOR AIRCRAFT HIGH POWER FINAL REPORT APR 1-MARCH 31, 1975

Meyer, A.P., Bell, W.F., (United Technologies Corp., South Windsor, CT, South Windsor Engineering Facility), 250 p., May 1975, AD-A014828, FCR-0003
Avail:NTIS

Pratt and Whitney Aircraft has conducted an analytical and experimental program which demonstrated the feasibility of an ultra-lightweight fuel cell powerplant with a specific weight of less than 0.5 lb/kw for advanced aircraft applications. Full-scale single cells and 12-cell development units, the basic modular repeating subsection of which a complete powerplant is assembled, were constructed and successfully tested. Power densities up to 3000 watts/sq ft were demonstrated; this level is almost 50 percent greater than that required for a competitive flightweight system. Endurance tests demonstrated an operating capability in excess of 600 baseline missions. Several complete power systems based on the as-demonstrated performance were defined. These systems included all equipment required for a flight operational installation; i.e., powerplants, a reactant supply system and a cooling water supply system. Each offers the advantages of instant "on-off" power supply capability and modular design. Modular design provides the flexibility to meet a broad range of air force mission requirements without adverse impact on performance or development schedule and cost.

(AIRCRAFT, FUEL CELLS, FEASIBILITY)

H77 34650 COMPARISON OF POROUS SILVER CATALYSTS IN O_2 ELECTRODES OF ALKALINE FUEL CELLS

Mund, K., (Siemens A.G., Erlangen, Germany, Forschungslaboratorium), Siemens Forsch.-Entwicklungsber, V5:209-216, N4, 14 refs., 14 figs., 2 tabs., 1976, In German

In the present work a) concepts treated in the literature on the reaction course of the electrochemical reduction of oxygen on silver electrodes are outlined, b) the exchange current density on a rotating silver electrode is determined, c) various silver catalysts are described, d) the stationary polarization of supported silver electrodes is calculated and compared with measured potential current density curves and finally, e) the causes of the polarization are determined using impedance measurements.

(SILVER CATALYSIS, HYDROGEN FUEL CELLS)

H77 34850 FUEL PROCUREMENT FOR FIRST GENERATION FUSION POWER PLANTS

Gore, B.F., Hendrickson, P.L., (Battelle Pacific Northwest Labs., Richland, WA), 30 p., Sept 1976, BNWL-2012

The provision of deuterium, tritium, lithium and beryllium fuel materials for fusion power plants is examined in this document. Possible fusion reactions are discussed for use in first generation power plants. Requirements for fuel materials are considered. A range of expected annual consumption is given for each of the materials for a 1000 megawatts electric (MWe) fusion power plant. Inventory requirements are also given. Requirements for an assumed fusion power plant electrical generating capacity of 10 exp 6 MWe (roughly twice present U.S. generating capacity) are also given. The supply industries are then examined for deuterium, lithium and beryllium. Methods are discussed for producing the only tritium expected to be purchased by a commercial fusion industry--an initial inventory for the first plant. Present production levels and methods are described for deuterium, lithium and beryllium. The environmental impact associated with production of these materials is then discussed. The toxicity of beryllium is described and methods are indicated to keep worker exposure to beryllium as low as achievable.

(DEUTERIUM FUEL, FUSION, ENVIRONMENTAL IMPACT)

H77 34851 FIRST INTERNATIONAL CONFERENCE "CONVERSION OF REFUSE INTO ENERGY"

Rasch, R., Aufbereit-Tech, V17:88-90, N2, Feb 1976, From 1. international conference on conversion of refuse into energy; Montreux, Switzerland, Nov 3, 1975, In German

A discussion is given on lectures presented at a meeting on the use of wastes as energy sources. Waste processing by the following methods were discussed: (1) mechanically by processing and briquetting; (2) biologically by anaerobic and aerobic treatment; (3) thermally by drying and degasification (pyrolysis); (4) chemically by gasification (synthesis gas) and hydrogenation; and (5) energetically by gasification (fuel gas) and combustion.

(WASTE UTILIZATION, PROCESSING, HYDROGENATION)

IV. TRANSMISSION, DISTRIBUTION, AND STORAGE

H77 40011 SHOCK COMPRESSION OF LIQUID HYDROGEN IN VARIOUS EXPERIMENTAL GEOMETRIES

Bordzilovskii, S.A., Silvestrov, V.V., Titov, V.M., (Akademiia Nauk SSSR, Institut Gidrodinamiki, Novosibirsk, USSR), Acta Astronautica, V3:1015-1032, Nov-Dec 1976, Colloque International Sur La Dynamique Des Gaz En Explosion Et Des Systemes Reactifs, 5th, Bourges, France, Sept 8-11, 1975, A77-27918

Shock wave processes in liquid hydrogen were investigated under plane, cylindrical and hemispherical loading. The quasi-one-dimensional extrusion model of Fadeenko Et Al. (1974) is refined for the purpose of evaluating and discussing the results. This model is shown to be only a limited approximation of the explosive compression of cylindrical containers. In reality, a multidimensional nonsteady flow takes place which is strongly influenced by emerging boundary layers. Use of hemispherical implosion makes it possible to generate a shock wave in liquid hydrogen with pressures reaching approximately 200 KBAR.

(IMPLOSION, SHOCK WAVE PROCESSES, FLOW)

H77 40221 HEAT RELEASE DURING BOILING OF HYDROGEN IN A LARGE VOLUME

Kirichenko, I.A., Levchenko, N.M., Kozlov, S.M., (Akademiia Nauk Ukrainskoi SSR, Fiziko-Tekhnicheskii Institut Nizkikh Temperatur, Kharkov, Ukrainian SSR), Teploenergetika, p. 60-63, Apr 1977, A77-35097, In Russian

In the experiment described, horizontal and vertical tubular stainless-steel heaters were used to study heat release coefficients for bubble boiling of hydrogen over a wide range of saturation pressures. Visual observations were made of the behavior of boiling at low saturation pressures, including bubble growth; decrease in number of evaporation centers; decrease in bubble separation frequency; and irregularity of separation at a triple point. The experimental relationships obtained are diagrammed and discussed.

(HEAT EXCHANGERS, HEAT RELEASE COEFFICIENTS, BUBBLE BOILING)

H77 40434 INVESTIGATION OF LIGHTWEIGHT DESIGNS AND MATERIALS FOR LO_2 AND LH_2 PROPELLANT TANKS FOR SPACE VEHICLES, PHASE 2 AND PHASE 3 FINAL REPORT

Anon, (General Dynamics/Convair, San Diego, CA), NASA-CR-150223, 226 p., PD-76-0200, NAS8-31370, N77-20156
Avail:NTIS

Full size tug LO_2 and LH_2 tank configurations were defined, based on selected tank geometries. These configurations were then locally modeled for computer stress analysis. A large subscale test tank, representing the selected tug LO_2 tank, was designed and analyzed. This tank was fabricated using procedures which represented production operations. An evaluation test program was outlined and a test procedure defined. The necessary test hardware was also fabricated.

(TANK CONFIGURATIONS, COMPUTER STRESS ANALYSIS, TEST PROCEDURES)

H77 40435 MECHANICAL BEHAVIOR OF ABLATOR/INSULATOR MATERIALS--FOR SPACECRAFT CRYOGENIC REUSABLE STORAGE TANKS

Adsit, N.R., May, L.C., (General Dynamics Corp., Convair Div., San Diego, CA), Society for the Advancement of Material and Process Engineering, Azusa, CA, p. 736-742, 1976, In Bicentennial of Materials Progress; Proceedings of the Twenty-first National Symposium and Exhibition, Los Angeles, CA, Apr 6-8, 1976, Research Supported by the General Dynamics Corp., A77-27451 11-23, A77-27499

The mechanical behavior of several ablator/insulator materials for tanks used in space flight was measured over the temperature data was due to aerodynamic heating during the reentry cycle of reusable tanks. Tension, compression and shear tests were performed to fully characterize the mechanical behavior of these materials. From these tests, the strength (tension, compression, and shear) and elastic modulus were determined for each material at each test temperature. It is shown that strength and modulus are strongly related to the test temperature and can vary by two orders of magnitude in the temperature range observed. The epoxy-base materials appear to be less temperature-dependent than the elastomeric or polyurethane base materials.

(ABLATIVE MATERIALS, MECHANICAL PROPERTIES, SPACE FLIGHT)

H77 40436 FRACTURE TOUGHNESS OF CRYOGENIC ALLOYS AND DETERMINATION OF THEIR STRUCTURAL STRENGTH

Alymov, V.T., Alekseev, S.I., Kozelkin, V.V., Mozhaev, A.V., Metallovedenie I Termicheskaia Obrabotka Metallov, p. 35-39, N8, 1976, Metal Science and Heat Treatment, V18:699-703, N7-8, Jan 1977, Translation, A77-25939

Sum diverse data are presented; variables include breaking load, depth of semielliptical surface crack, crack length, sample thickness, fracture toughness, testing temperature, annealing temperature, aging temperature, tempering temperature, alloy composition.

(CRYOGENIC ALLOYS, FRACTURE TOUGHNESS)

H77 40437 THERMAL PERFORMANCE OF AN INTEGRATED THERMAL PROTECTION SYSTEM FOR LONG-TERM STORAGE OF CRYOGENIC PROPELLANTS IN SPACE

Dewitt, R.L., Boyle, R.J., (NASA, Lewis Research Center, Cleveland, OH), NASA-TN-D-8320 E8881, 109 p., N77-24183
Avail:NTIS

It was demonstrated that cryogenic propellants can be stored unvented in space long enough to accomplish a saturn orbiter mission after 1,200-day coast. The thermal design of a hydrogen-fluorine rocket stage was carried out and the hydrogen tank, its support structure, and thermal protection system were tested in a vacuum chamber. Heat transfer rates of approximately 23 W were measured in tests to simulate the near-earth portion of the mission. Tests to simulate the majority of the time the vehicle would be in deep space and sun-oriented resulted in a heat transfer rate of 0.11 W.

(STORAGE TANK DESIGN, THERMAL INSULATION, SPACECRAFT)

H77 40438 PROBLEMS IN LH_2/LOx ROCKET TANK DESIGN

Fujii, T., Kitamura, K., Kando, T., Yoshida, Y., Ishikawajima-Harima Engineering Review, V16:702-714, Nov 1976, A77-25716, In Japanese, with abstract in English

Development of a technique for efficient utilization of liquid hydrogen (LH_2) is central to the elaboration of an improved rocket system burning LH_2/LOx propellant, for launching Japanese heavy artificial satellites in future programs. Mechanical engineering problems discussed in relation to the design of the rocket tank include tank shell materials selection, tank insulation, evaluation of applied loads and liquid sloshing and buckling and fracture strength of the shell and estimates of pressure rises and thermal stratification inside the tank.

(TANK DESIGN, FRACTURE STRENGTH, THERMAL STRATIFICATION)

H77 40439 DEVELOPMENT AND VALIDATION OF PURGED THERMAL PROTECTION SYSTEMS FOR LIQUID HYDROGEN FUEL TANKS OF HYPERSONIC VEHICLES

Helenbrook, R.D., (Bell Aerospace Co., Buffalo, NY), Colt, J.Z., (Little, Arthur D., Inc., Cambridge, MA), NASA-CR-2829, 124 p., Rept-8653-950001, NAS1-10969, N77-25455
Avail:NTIS

An economical, lightweight, safe, efficient, reliable and reusable insulation system was developed for hypersonic cruise vehicle hydrogen fuel tanks. Results indicate that, a nitrogen purged, layered insulation system with nonpermeable closed-cell insulation next to the cryogenic tank and a high service temperature fibrous insulation surrounding it, is potentially an attractive solution to the insulation problem. For the postulated hypersonic flight the average unit weight of the purged insulation system (including insulation, condensate and fuel boil off) is 6.31 KG/Sq M (1.29 PSF). Limited cyclic tests of large specimens of closed cell polymethacrylimide foam indicate it will withstand the expected thermal cycle.

(FUEL TANKS, INSULATION SYSTEM, THERMAL CYCLE)

H77 40440 INVESTIGATION OF LIGHTWEIGHT DESIGNS AND MATERIALS FOR LO_2 AND LH_2 PROPELLANT TANKS FOR SPACE VEHICLES, PHASE 1 INTERIM REPORT

Anon, (General Dynamics/Convair, San Diego, CA), NASA-CR-150222, 134 p., PD-75-0117, NAS8-31370, N77-20155
Avail:NTIS

Design, analysis and fabrication studies were performed on nonintegral (suspended) tanks using a representative space tug design. The LH_2 and LO_2 tank concept selection was developed. Tank geometries and support relationships were investigated using tug design propellant inertias and ullage pressures. Then compared based on total tug systems effects. The tank combinations which resulted in the maximum payload were selected. Tests were conducted on samples of membrane material which was processed in a manner simulating production tank fabrication operations to determine fabrication effects on the fracture toughness of the tank material. Fracture mechanics analyses were also performed to establish a preliminary set of allowables for initial defects.

(PROPELLANT TANKS, STRUCTURAL DESIGN, MEMBRANE MATERIAL TESTS)

H77 40515 SMALL, HIGH-PRESSURE LIQUID HYDROGEN TURBOPUMP FINAL REPORT, AUG 1973-APR 1976

Csomor, A., Sutton, R., (Rocketdyne, Canoga Park, CA), NASA-CR-135186, 278 p., R76-115, NAS3-17794, N77-23488
Avail:NTIS

A high pressure, liquid hydrogen turbopump was designed, fabricated and tested to a maximum speed of 9739 Rad/s and a maximum pump discharge pressure of 2861 N/sq. cm. The approaches used in the analysis and design of the turbopump are described and fabrication methods are discussed. Data obtained from gas generator tests, turbine performance calibration and turbopump testing are presented.

(DESIGN ANALYSIS, TURBOPUMP, TURBINE CALIBRATION)

H77 40516 SUBMERGED LIQUID HYDROGEN PUMP

Rival, J., (Commissariat A L'energie Atomique, Laboratoire D'Applications Speciales de la Physique, Grenoble, France), IPC Science and Technology Press, LTD., Guildford, Surrey, England, p. 231-234, 1976, In International Cryogenic Engineering Conference, 6th, Grenoble, France, May 11-14, 1976, Proceedings, A77-26532 10-31, A77-26545

Basic elements for a rotating machine submerged in cryogenic fluid are studied. Rolling-element bearings are of the angular contact type and have bronze-filled PTFE separators, the number of balls being 15. The electric motor is 3-phases, asynchron, squirrel cage. The output power is 500 W at 300 K and 1200 W at 20 K. For these temperatures the iron-losses increase for 20 percent but the efficiency reaches 90 percent. A pump may be built with these elements, the characteristics are given for liquid hydrogen. Other devices may be used in a closed loop or a transfer line.

(CRYOPUMPING, BALL BEARINGS, PUMP ELEMENTS)

H77 40517 FRACTURE CONTROL OF H-O ENGINE COMPONENTS--TITANIUM TIN ALLOY FUEL PUMP IMPELLERS FINAL REPORT, JUNE 17, 1974-AUG 5, 1976

Ryder, J.T., (Lockheed-California Co., Burbank, CA), (General Dynamics/Convair, San Diego, CA), (International Harvester Co., Chicago, IL), (Ladish Co., Cudahy, WI), NASA-CR-135137, 489 p., LR-27810, NAS3-18896, N77-20207
Avail:NTIS

An investigation was made to obtain the material characterization and fatigue crack propagation data necessary to establish the salient characteristics of a TI-6AL-2.5SN(ELI) alloy fuel pump impeller to be used in a cryogenic service environment. Testing variables considered were coupon orientation, frequency, load range ratio and temperature. Data analysis correlated crack propagation data from conventional laboratory coupons with data from a parallel sided rotating disk used to model rotor stresses. Four major design recommendations when bore regions of fuel pump impellers to be operated in cryogenic environments are to be relatively highly stressed are discussed.

(CRYOPUMPING, MATERIAL CHARACTERIZATION, FATIGUE LIFE)

H77 40618 PROSPECTS FOR PIPELINE DELIVERY OF HYDROGEN AS A FUEL AND AS A CHEMICAL FEEDSTOCK

Gregory, D.P., Biederman, N.P., Darrow, K.G. Jr., Konopka, A.J., Wurm, J., (Institute of Gas Technology, Chicago, IL), 23 p., 1976, CONF-760581-2, From American Gas Association Transmission Conference, Las Vegas, NV, May 3, 1976

The propsects for hydrogen pipelining over long distances are very real, as is the need to develop this capability. The technical problems involved do not appear to be too severe, but there are still some unknown quantities that require research and development, not the least of which is concerned with possible hydrogen embrittlement. The gas industry has many opportunities to become involved with future energy technology by means of its present capability to transmit gaseous energy over long distances. The initial concept of the "hydrogen economy" was a somewhat idealistic approach to solving the national energy problem with a completely new energy distribution system. After a few years of study of this concept, some rather more realistic and somewhat more limited options are emerging that will involve the pipelining of hydrogen and should involve the gas industry.

(FEASIBILITY, PIPELINES, HYDROGEN ECONOMY)

H77 42016 PROSPECTS FOR PIPELINE DELIVERY OF HYDROGEN AS A FUEL AND AS A CHEMICAL FEEDSTOCK

Gregory, D.P., Biederman, N.P., Darrow, K.G. Jr., Konopka, A.J., Wurm, J., (Institute of Gas Technology, Chicago, IL), American Gas Association Monthly, V58:24-31, Nov 1976, Research supported by the American Gas Association, Electric Power Research Institute and NASA, A77-29437

The possibility of using hydrogen for storing and carrying energy obtained from nonfossil sources such as nuclear and solar energy is examined. According to the method proposed, these nonfossil raw energy sources will be used to obtain hydrogen from water by three basically distinct routes (1) electrical generation followed by electrolysis; (2) thermochemical decomposition; and (3) direct neutron or ultraviolet irradiation of hydrogen bearing molecules. The hydrogen obtained will be transmitted in long-distance pipelines and distributed to all energy-consuming sectors. As a fuel gas, hydrogen has many qualities similar to natural gas and with only minor modifications, it can be transmitted and distributed in the same equipment and can be burned in the same appliances as natural gas. Hydrogen can also be used as a clean fuel (water is the only combustion product) for automobiles, fleet vehicles and aircraft.

(DISTRIBUTION, COST EFFECTIVENESS, PIPELINES, NON FOSSIL RESOURCES)

H77 42017 STRUCTURAL MATERIALS FOR ENERGY STORAGE

Robinson, S.L., West, A.J., Saxton, H.J., (Sandia Lab., Albuquerque, NM), 31 p., Jan 1976, N77-15134

Work on the hydrogen compatibility of structural materials for pressure vessels and pipelines is proceeding along several fronts. The tensile behavior of a number of carbon and pressure vessel steels in high pressure hydrogen gas and in contact with iron-titanium hydride was characterized. Slow crack growth studies of pressure vessel steels are nearing completion. Studies addressing the protective value of brush electroplated coatings are being continued. A new silicon coating applied by vapor deposition is also under study. Self-loaded tensile specimens are being prepared in an in-situ accelerated test program. Efforts are underway to modify the hydrogen compatibility of manganese-carbon and high carbon steels by thermomechanical treatment and to characterize their mechanical properties and microstructures. The effects of chemical segregation on hydrogen cracking are also being studied. Construction of the experimental hydrogen pipeline is proceeding satisfactorily with initial safety tests to be performed soon.

(STORAGE, HYDROGEN COMPATIBILITY, PIPELINES)

H77 43078 DEVICE FOR CONVERTING CALORIC INTO MECHANICAL

Meijer, R.J., German Patent 2,110,042/B, 6 p., 4 fig., Jan 15, 1967, Philips Gloeilampenfabrieken N.V., In German

The invention relates to: a) a combination of a hot-gas engine heated with hydrogen and hydrogen storage on the basis of metal hydrides, b) a favorable use of the waste heat for the desorption of the hydrogen stored in the form of hydrides, c) the carry-off of the hydride formation heat during the hydrogen charging of the hydride storage, d) the chemical composition of the hydrides-forming alloys.

(STORAGE, WASTE HEAT UTILIZATION, CHEMICAL COMPOSITION HYDRIDES)

H77 43079 METAL HYDRIDES AS HYDROGEN STORAGE MEDIA AND THEIR APPLICATIONS

Reilly, J.J., (Brookhaven National Lab., Upton, NY, Dept. of Applied Science), 88 p., July 14, 1976, (Contract E(30-1)-16), BNL-21648, N77-20589

The four hydride systems of current interest for hydrogen storage applications are the hydrides of magnesium and certain of its alloys, iron titanium alloys, vanadium and lanthanum pentanickel (or AB5) type alloys. Peak shaving, automotive, thermal storage and solar energy and pumps and compressors are some of the areas of application.

(MAGNESIUM HYDRIDES, APPLICATIONS, SOLAR ENERGY)

H77 43080 HYDROGEN STORAGE VIA METAL HYDRIDES FOR UTILITY AND AUTOMOTIVE ENERGY STORAGE APPLICATIONS

Salzano, F.J., Braun, C., Beaufrere, A., Srinivasan, S., Strickland, G., (Brookhaven National Lab., Upton, NY), 54 p., Aug 1976, CONF-761044-1, BNL-21723

Brookhaven National Laboratory is currently supported by ERDA to develop the technology and techniques for storing hydrogen via metal hydrides. The use of these systems for hydrogen storage involves the design of heat exchanger and mass transfer systems, i.e. removal of heat during the charging reaction and addition of heat during the discharge reaction. Recent work and progress on the development of metal hydrides for hydrogen storage connected with utility energy storage applications and natural gas supplementation are discussed and electric-to-electric storage system is described in some detail. A system of energy storage involving the electrolysis of hydrochloric acid is described which would utilize metal hydrides to store the hydrogen. In addition, the use of metal hydrides for hydrogen storage in automotive systems is described.

(HYDRIDES, ELECTRIC STORAGE SYSTEM, HYDROCHLORIC ACID ELECTROLYSIS)

V. SAFETY

H77 51017 EXPERIMENTAL STUDY OF HYDROGEN FORMATION AND RECOMBINATION UNDER POSTULATED LMFBR ACCIDENT CONDITIONS

Wierman, R.W., Hilliard, R.K., (Hanford Engineering Development Lab., Richland, WA), 58 p., Dec 1, 1976, (Contract EY-76-C-14-2170), HEDL-TC-730

The report describes an experimental study of hydrogen jets burning in air, hydrogen formation by solium in humid air atmospheres and the effects of nitrogen, water vapor sodium vapor/aerosol, jet velocity and jet temperature on ignition of hydrogen jets. The results show that hydrogen jets above 1450°F (788°C) issuing into an air atmosphere need no ignition source for ignition, a hydrogen jet temperature higher than 500°F (260°C) and containing more than six grams of sodium per cubic meter of jet gas will auto-ignite in an air atmosphere, the burning efficiency of a hydrogen jet decreases rapidly to zero when the oxygen concentration outside the flame region approaches 10 percent, and hydrogen does not form from a sodium-nitrogen jet issuing into a humid air atmosphere until the ratio $O_2/H_2O + O_2)$ is less than 0.5.

(ACCIDENT CONDITIONS, CHEMICAL REACTIONS, IGNITION)

H77 52161 HYDROGEN COMPATIBILITY OF STRUCTURAL MATERIALS FOR ENERGY STORAGE AND TRANSMISSION APPLICATIONS. SEMI-ANNUAL REPORT FOR PERIOD THROUGH OCTOBER 1, 1976

Robinson, S.L., (Sandia Labs., Albuquerque, NM), 69 p., Dec 1976, SAND-76-8255

Substantial support activities for Brookhaven National Laboratory (BNL) have been completed since the initiation of this program. The suitability of commercial alloys for containment of hydride-dehydride reactions have been assessed and recommendations for materials selection based upon tensile and slow crack growth tests have been made. We have also prepared and installed in a test chamber at BNL a series of insitu test specimens to be exposed to a cyclic iron-titanium hydride environment. A preliminary welding specification for containment of hydrogen in structural mild steels has been developed. Hydrogen permeation resistant coatings, applied by pyrolysis of silane, and by brush electroplating, have been developed. Environmentally assisted, cyclic fatique in high-pressure hydrogen has been identified as a potential hazard to the integrity of flawed pressure vessels in materials where slow crack growth under constant load is not expected.

(HYDRIDE REACTION VESSELS, STORAGE, STRUCTURAL FATIGUE)

H77 52162 MATERIALS COMPATIBILITY ANALYSIS

Brown, P.E., DeSantis, V.J., Sayell, E.H., (AiResearch Mfg. Co. of Airzona, Phoenix, AZ), 74 p., Nov 26, 1975, GE-BIPS-03-001

The use of the MHW-IHS in the MJS configuration as the heat source for the BIPS-GDS, exposes a bare graphite structure to the inside of the HSHX, the design of which currently uses the niobium alloy, C-103. Data from the MHW-IHS studies showed CO/CO sub 2 was evolved in storage and under operational conditions, from the Carbon/Graphite components which were insufficiently degassed before assembly. A satisfactory method for removing gases from the MHW-IHS has been defined to assure acceptable levels of CO/CO sub 2 in the MJS converter. However, it is recognized that the Nb and Ta alloys are degraded in their mechanical properties by both carbon and oxygen. Consequently, there is concern that for prolonged exposures, 10 exp 5 hours, the Nb alloy of the HSHX may be adversely affected even by very low concentrations of CO/CO sub 2, O sub 2, H sub 2 O, and H sub 2. A materials evaluation study was begun to review the potential problems and to indicate proposed solutions.

(NIOBIUM ALLOY, MATERIALS EVALUATION)

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